

**Hazard and Risk Analysis for Selecting Safety Standards:  
Experience From the Necessary and Sufficient Pilot Demonstration  
at Lawrence Livermore National Laboratory**

by  
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### **Introduction**

The DOE Department Standards Committee has commissioned pilot demonstrations (formally termed Necessary and Sufficient Set of Standards Pilot Demonstrations) to be carried out at selected DOE sites, of which Lawrence Livermore National Laboratory (LLNL) is one. The Hazards analysis is an essential component of the work evaluation to select standards, that when implemented, will protect those performing the work, the public and the environment. A Hazards Analysis & Standard Identification Team (HASIT) was formed to accomplish two tasks. The first was to identify the **operations, hazards, and existing standards** associated with HWM radioactive waste operations. The second was to evaluate the *relative risk* —during normal radioactive waste operations — to the worker, the public, and the environment. It was determined by the HASIT that the input needed for subsequent process elements could be provided by a qualitative, relative risk methodology to identify, rank, and screen HWM operations using a consensus of expert opinion to assign consequence and possibility.

### **Scope for Pilot**

The scope of the pilot demonstration at LLNL focuses on radiological waste management activities, including low-level waste, transuranic waste, and the radiological component of these types of mixed waste. A risk-based method for evaluating the operational hazards was required to satisfy the pilot's *Necessary and Sufficient Set of Standards Closure Process Element 1*. The radioactive waste operations and consequences were evaluated for two categories of hazards.

1. Those hazards identified during this pilot demonstration associated with normal and routine HWM radioactive waste management operations.
2. Those hazards associated with the **postulated accident events** identified in the HWM Draft Safety Analysis Report, the LLNL Environmental Impact Statement/ Environmental Impact Report, and the Facility Safety Procedures.

### **Development of Hazard Assessment Matrix**

A primary goal for this hazards analysis methodology was to assure that the full range of possible hazards during all modes of operation is represented and considered. Accomplishing this goal did not require that every individual hazard source or initiating event be detailed to determine if it resulted in an undesired consequence. It was determined that significant time and resource savings were possible and that the goals of the pilot demonstration can be achieved by inverting the conventional risk analysis process. The HASIT attempted (in their discussions of specific consequences) to identify the hazards for a given consequence. For example, a standard hazard analysis would define a high voltage electrical source as a hazard with presently unspecified consequences. To determine the consequences, it would be necessary to perform a fault or event tree analysis to trace all the possible safety consequences, such as electrical shock of a worker, or as an ignition source for an explosive gas. The HASIT used the inverse analysis process that started with the consequence of interest and determined which hazards were present to cause that consequence.

The **hazards assessment matrix (HAM)** was developed as a tool for the HASIT. The HAM was used to document the results of this process and was an effective method of collecting, documenting, and evaluating the technical information provided by HASIT participants. The HAM consists of a table that defines the scope of the review by identifying all the radioactive waste operations (by rows) and their possible consequences (by columns) for this pilot demonstration. The HAM is modeled after **Table 3-1** from DOE-STD-3009-94. The HAM also served as a table to document the relative risk parameters

(for each row and columns combination) and ranking for each operation. The HAM provided a tractable and systematic approach that took advantage of experience gained in implementing more quantitative probabilistic assessment. A bottom-up approach was used to identify the full set of operations for radioactive waste management at HWM. The initial step was to extract a comprehensive list of current operations from the HWM activity scope and budget plan. The operations with similar tasks and/or processes were grouped into four main categories containing 17 operational subcategories. The main categories for operations are 1. Waste Handling Operations, 2. Facility Operations, 3. Transportation, 4. Processes and Operations.

### **Consequences Categories**

The breadth of consequences possible for HWM radioactive waste operations were also compiled by the HASIT, associated with the operations, and were grouped into three main categories according to their impact on the worker, the public, and the environment. The selected categories for consequences are: 1. Radioactive Exposure and Release, 2. Radioactive Release to Environment, 3. Industrial Safety and Health.

The three categories contain an aggregate of 18 distinct subgroups. (e.g., the subgroup Soil Contamination is part of the main group Radioactive Release to the Environment).

For each operation reviewed by the HASIT, using the consequences instead of hazards in a bottom-up approach provided three benefits.

1. It assured that the scope of the pilot demonstration was satisfied by defining the boundaries of the problem — consequences related only to safety of the worker, the public, and the environment.
2. It expedited the process by eliminating the need to examine every HWM hazard, accident, or initiating event.
3. Using the consequence as the focal point for discussion lead directly to the relative risk ranking, which by definition is a function of the consequence and the possibility of occurrence.

### **Expert Judgement**

The relative risk analysis developed for this process can be described as basically a task and/or hazard analysis using expert opinion. HASIT members used their experience and expert judgment as a basis for ranking the hazardous consequences and operations on an ordinal rank order scale of high, moderate, and low. A rule was made to require consensus amongst the diverse subject matter experts. It was found that open discussions between experts with different regulatory interests and the requirement for consensus provided the benefits listed below.

1. Immediately aggregated the independent opinions.
2. Reduced biasing of the ranking with special interest.
3. Increased validity by identifying and resolving inconsistencies and lack of agreement.

The use of expert judgment has been explored to determine its reliability and validity in assessing human error probabilities for the Nuclear Regulatory Commission. The literature suggests that expert judgment can be used effectively, if appropriate care is given to the manner in which judgments are obtained.

The technique adopted for this process was used for both ranking of the severity level of a consequence category and assigning of possibilities of occurrence for a specific operation category.

### **Relative Ranking**

This section discusses how the subject matter experts used the HAM to document and assess these properties for the HWM radioactive waste operations. As discussed in the previous sections, these properties include the types of hazards, the possibility of the hazard to result in an undesirable consequence, and the severity level of the hazard's consequences. The assessment required a valid, reliable, and systematic means to assign and evaluate the properties.

Two techniques, titled global and individual, were proposed for assessing the relative risk of an operation based on its properties. The two techniques are distinguished by their methods to:

1. Assign a severity level to a hazard consequence.
2. Develop an algorithm to evaluate the properties.

The **global** ranking method used a global or constant value for ranking each severity of consequences (H, M, or L is constant down each column in the HAM). The optional, **individual** ranking method individually or uniquely assigned a consequence severity level to each operation (H, M, or L varies by rows in the HAM). Possibilities for the occurrence of an event were assigned similarly, but separately for the two methods and then compared.

Both techniques were suitable for providing a qualitative review of the HWM radioactive waste operations, but the individual method required a higher resolution for review (i.e., more time and resources) than was necessary to meet the goals of the pilot demonstration. Therefore, the global method was adopted by the HASIT for the hazard assessment because of its ability to be applied by a large group in a short time frame. It was found that the ranking results of the individual method were similar to the global method. The group decided to evaluate the final hazards ranking as a normalized composite of both the global and individual methods.

### **Results and Conclusions**

The expert estimation techniques combined with the global method for this task provided a qualitative relative risk analysis that was reliable and valid.

The final set of relative risk values in the HAM illustrated that correlation between the global and individual methods was reasonable, and that the composite of both methods further validates the process by averaging the results. Comparing and combining both the global and individual methods of assigning a severity to the consequence has proven to be a useful process. Using both methods for ranking helped us understand the uncertainties and sensitivities, particularly when using a coarse, qualitative evaluation method with only a three-bin scale.

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